Clpto

October 27, 2004

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1. A single crystal gallium nitride substrate having a top surface and a bottom surface, comprising:

a closed defect accumulating region (H) including a core (S) penetrating the substrate and containing many accumulated defects and a grain boundary (K) enclosing the core (S),

an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and being a single crystal of a basic orientation with low dislocation density, and

an extra low dislocation single crystal regions (Y) lying outside of the accompanying low dislocation single crystal region (Z) and being a single crystal with the same basic orientation as the accompanying low dislocation single crystal regions (Z).

2. A single crystal gallium nitride substrate having a top surface and a bottom surface, comprising a plurality of fundamental units (Q),

the fundamental unit (Q) containing;

a closed defect accumulating region (H) including a core (S) penetrating the substrate and containing many accumulated defects and a grain boundary (K) enclosing the core (S),

an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and being a single crystal of a basic orientation with low dislocation density, and

an extra low dislocation single crystal regions (Y) lying outside of the accompanying low dislocation single crystal region (Z) and being a single crystal with the same basic orientation as the accompanying low dislocation single crystal regions (Z).

3. A single crystal gallium nitride substrate according to Claim 2, wherein the closed

defect accumulating region (H) is a polycrystal and the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y) build a common single crystal of the basic orientation.

4. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which is different from the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

5. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which is common only in a <0001> direction with the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

6. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) is a single crystal with an orientation which has a <0001> direction reverse to a <0001> direction of the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

7. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain with an orientation which has a <0001> direction reverse to a <0001> direction of the basic orientation of the accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

8. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) consists of more than one crystal grain having an orientation slightly slanting to the basic orientation of the surrounding accompanying low dislocation single crystal region (Z) and the extra low dislocation single crystal region (Y).

9. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating region (H) is a single crystal having the basic orientation or more than one crystal grain being shielded by planar defects or linear defect assemblies from the surrounding accompanying low dislocation single crystal region (Z) and the closed defect accumulating region (H) includes crystal defects.

10. A single crystal gallium nitride substrate according to Claim 2, wherein the defects included in the closed defect accumulating region (H) are linear defects or planar defects.

11. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) have a diameter ranging from 1 μ m to 200 μ m and discretely disperse on the surfaces.

12. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) have a diameter ranging from 5 μ m to 70 μ m and discretely disperse on the surfaces.

13. A single crystal gallium nitride substrate according to Claim 2, wherein shapes of the closed defect accumulating regions (H) are amorphous, circular or polygonal.

14. A single crystal gallium nitride substrate according to Claim 2, wherein the dislocation density is less than $3 \times 10^{7} cm^{-2}$ at spots distanced by 30 μ m from the closed defect accumulating region (H) within the accompanying low dislocation single crystal region (Z).

15. A single crystal gallium nitride substrate according to Claim 2, wherein an average of dislocation density in the accompanying low dislocation single crystal regions (Z) and the extra low dislocation single crystal regions (Y) is less than $5 \times 10^{6} cm^{-2}$ and the dislocation density decreases in proportion to a distance from the closed defect accumulating region (H).

16. A single crystal gallium nitride substrate according to Claim 2, wherein the top surface is a (0001) plane.

17. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces

except the closed defect accumulating regions (H) are (0001) planes and top surfaces of the closed defect accumulating regions (H) are (000-1) planes.

18. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces except the closed defect accumulating regions (H) are GaN (0001) Ga planes and top surfaces of the closed defect accumulating regions (H) are GaN (000-1) N planes.

19. A single crystal gallium nitride substrate according to Claim 2, wherein top surfaces of the closed defect accumulating regions (H) are slightly lower than top surfaces except the closed defect accumulating regions (H).

20. A single crystal gallium nitride substrate according to Claim 2, wherein almost all the dislocations extend in parallel to a C-plane in the accompanying low dislocation single crystal regions (Z).

21. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) extend in a c-axis direction.

22. A single crystal gallium nitride substrate according to Claim 2, wherein the fundamental units (Q) which contain a center closed defect accumulating region (H), an accompanying low dislocation single crystal region (Z) surrounding the closed defect accumulating region (H) and an extra low dislocation single crystal region (Y) enclosing the accompanying low dislocation single crystal region (Z) are aligned periodically and regularly in a symmetric pattern formed in the substrate.

23. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a six-fold rotation symmetry pattern which aligns equivalent equilateral triangles in two dimensionally closest packed hexagonal symmetry and the fundamental units (Q) are disposed at corner points of the equilateral triangles of the pattern.

24. A single crystal gallium nitride substrate according to Claim 23, wherein a direction of a shortest repetition pitch which is equal to a side of the equivalent equilateral triangles of the hexagonal pattern is either a <1-100> direction or a <11-20> direction.

25. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a four-fold rotation symmetry pattern which aligns equivalent squares crosswise and lengthwise in series and the fundamental units (Q) are disposed at corner points of the squares of the pattern.

26. A single crystal gallium nitride substrate according to Claim 25, wherein a <1-100> direction is either a direction of a shortest repetition pitch which is equal to a side of the equivalent squares of the four-fold rotation summery pattern or a direction of a longest repetition pitch which is equal to an orthogonal line of the equivalent squares of the four-fold rotation summery pattern.

27. A single crystal gallium nitride substrate according to Claim 22, wherein the symmetric pattern is a two-fold rotation symmetry pattern which aligns equivalent rectangles or lozenges crosswise and lengthwise in series and the fundamental units (Q) are disposed at corner points of the rectangles or the lozenges of the pattern.

28. A single crystal gallium nitride substrate according to Claim 27, wherein a direction of a shortest repetition pitch which is equal to a shorter side of the equivalent rectangles or a shorter orthogonal line of the lozenge of the two-fold rotation symmetry pattern is either a <1-100> direction or a <11-20> direction.

29. A single crystal gallium nitride substrate according to Claim 22, wherein a shortest repetition pitch of the closed defect accumulating regions (H) ranges from 50 μ m to 2000 μ m on the surface regularly and periodically provided with the fundamental units (Q).

30. A single crystal gallium nitride substrate according to Claim 2, wherein the closed defect accumulating regions (H) extend in a c-axis direction and penetrate the substrate crystal.

CLAIMS 31-72 CANCELLED